IMPROVE THE EFFICIENCY OF AFFORESTATION BY THE USE OF ALLEY CROPPING SYSTEM

Kovács K[1], Vityi A[1]*

(1) Institute of Forest Mechanisation and Environmental Techniques, University of Sopron, Sopron, Hungary

*Corresponding author: vityi.andrea@uni-sopron.hu

Abstract

"Vákáncsos" is a traditional Hungarian practice where agricultural or horticultural crops were grown in the alleyways between spaced rows of woody plants in early stage in the 19th century. This study aimed at analyzing the results of the use of this old practice – in a modern form - in forest management. Results show that during the early stages of forest plantation, intercropping of young trees with food crops is beneficial in terms of the improvement of microclimate, tree development and survival, and food crop production.

Keywords: intercrop; alley cropping; forest management; tree; crop production; microclimate

Introduction

Agroforestry is a traditional practice in the Carpathian Basin. For example, abandoned forest areas owned by the city, where agricultural or horticultural crops are grown in the alleyways between spaced rows of woody plants were mentioned in the 1820s administrative records of the Municipality of Debrecen. These areas were called as "*vákáncs" from the latin "vacans"* (in English "vacant") which means "vacant land" (Miklós 1974). We considered, that the old practice used in these areas can be applied in forest management of today as well, but in a modern form adapted to the current (technological) environment. In this way, afforestation is manageable as a sustainable and productive system. The aim of the present research is to investigate the effect of intercropping between alleys on the soil microclimate and the development of seedlings, compared with a control site.

Materials and methods

In the summer of 2015, an experimental agro-forestry system was established in the area of Hajdúhadház Forestry Office of Nyírerdő Forestry Co (Vityi et al. 2016). The main purposes were to maximise the utilisation of available space, protect seedlings and ensure the success of afforestation. By using maize as intercrop in the alleys of the area replanted with oak trees fodder production for animal stock of the forestry company was also feasible. This experimental system provided possibility for measuring the effects of alley cropping on the local microclimate and the development of trees and thus on the success rate of afforestation. For this purpose, areas close to each other and of similar site conditions were involved in the experiment. The same tree row orientation and management were applied in both plots (Table 1).

Table 1: Basic data of the experimental areas.

	Alley cropping system	Control
Area	0,66 ha	4,0 ha
Plant	Oak (Quercus robur) and corn	Oak (Quercus robur)
Row spacing (cm)	90-70-90	250
Orientation of row	North-south	North-south
Irrigation	No	No
Physical characteristics of soil	Sandy soil with humus	Sandy soil with humus
Corn production	30q/ha	-
Experimental period	3 years	

Measurements

Based on the monitoring results of the first year (2015), an initial research plan was developed for the following year, focusing on the measurement of soil temperature and soil conductivity as well as the development of the crop and the seedlings. (Table 2) Parameters of soil microclimate were measured for one month, in the statistically most dry and hot period of summer which is a critical and stressful period of the year for the plants. Based on soil conductivity, comparison of soil moisture in the two areas is feasible, due to a strong correlation between the soil's electrical conductivity and the soil moisture content (Nagy 2014). In 2016, soil parameters were tested in two sampling points per area.

Sampling points were designated to have the same site conditions, thus ensuring the comparability of the samples. Due to the sloping terrain of the control area, it has a tendency to soil erosion and leaching, thus sampling sites were selected lowland, in a more fertile part of area similar to the alley cropping area. Also the distance between two sampling points and thus covering of the sampled area was equal.

In order to increase the reliability of the results, the number of sampling points were raised to 17 in each plots (Table 2).

Table 2: Measured parameters of the experimental plots (August 2016, 2017).

Examined parameter	Soil temperature	Soil conductivity	Growth of trees
Period	01. Aug. - 02. Sept.	01. Aug. - 02. Sept.	02. Sept.
Sampling points	2 points/plot (2016) 17 points/plot (2017)	2 points/plot (2016) 17 points/plot (2017)	5x10 meters/plot
Test method and equipment	Soil temperature and conductivity meter (Hanna HI 98331)	Soil temperature and conductivity meter (Hanna HI 98331)	Height measurement with measuring tape

Results

The results show that the daily average soil temperature data in the agro-forestry area were below the soil temperature values of the control area, which indicated a moderated soil

microclimate in the alley cropping system. (Figure 1 and Figure 2) In the average daily soil temperature there was a difference of 0.2-2.0 ° C between the two areas, which influenced the evaporation intensity and the growth of the plants. The reason for the curtail of the function is the precipitation on August 22 which did not allow the measurement to be carried out. Based on the results under the same soil conditions, we can infer that due to the presence of the intercrop, the soil moisture conditions of the two areas are different.

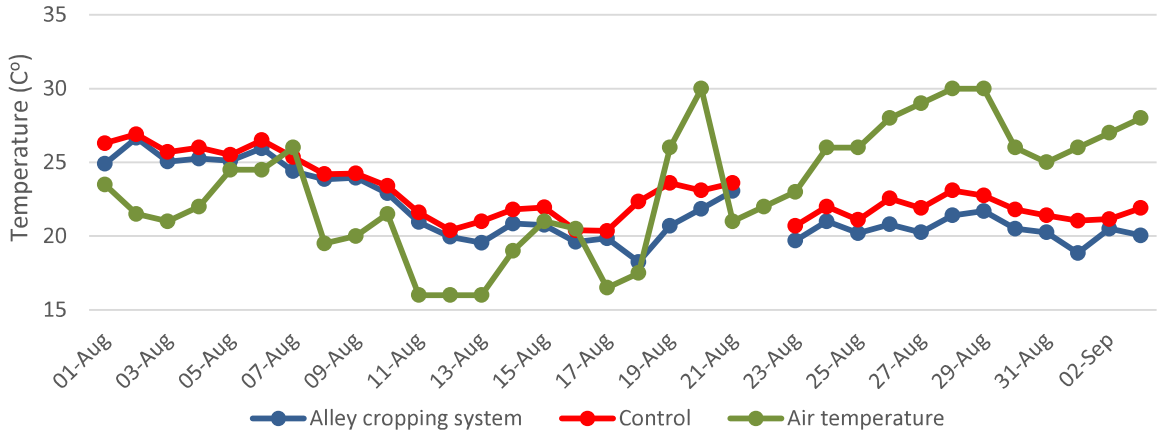

Figure 1: The change of daily average of soil temperature in August 2016.

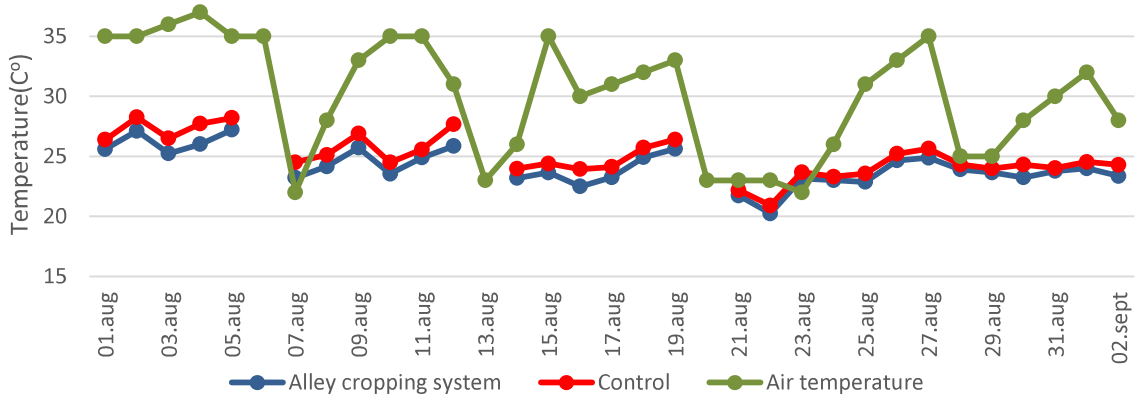

Figure 2: The change of daily average of soil temperature in August 2017.

The conductivity values of the soils follow well the distribution of precipitation, but in alley cropping system area the soil conductivity exceeded the values of the control area, in concluding that the agro-forest parcel had more favourable soil moisture values during drought period (Figure 3 and Figure 4).

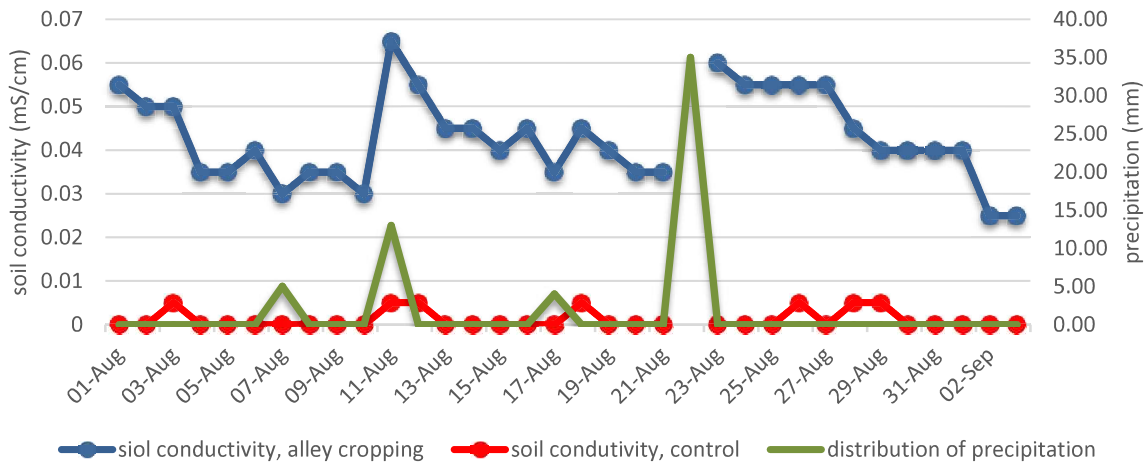

Figure 3: The change of daily average of soil conductivity (August 2016).

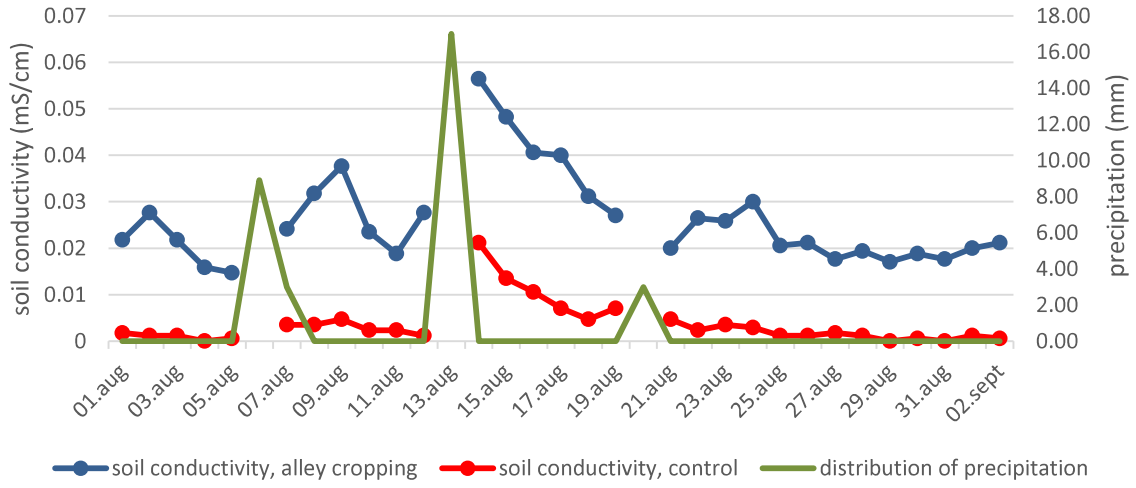

Figure 4: The change of daily average of soil conductivity (August 2017).

Results of tree development and rate of survival show that there is a significant difference between the agroforestry and the control systems. In 2015 the mortality rate was 50% in the control plot, requiring double plant replacement, on the contrary in the agroforestry parcel no drought damages were recorded (both systems are non-irrigated). Additionally, in the following years, the trees in the alley cropping plot showed significantly better growing, on average 18 cm (2016) and 21 cm (2017) ($t<0.05$; $p=0.0023$). The yield of the intermediate crop (60 q/ha) reached the average yield in monocultures under similar conditions.

Discussion and conclusion

Based on the results, the water balance of agroforestry system proved to be better than the control area in the examined drought periods. Significant difference was found between the data of the two afforested parcels in terms of soil microclimate. The daily mean temperatures of the alley cropping area in the arid period are significantly smaller than the values of the control area. The more favourable microclimate resulted in a significantly stronger growth of alley cropping area. There was no noticeable drought damage in the agro-forestry experimental field and the growth parameters of the plants were more favourable, so it can be established that in the

cultivation system associated with maize the development of the stand was more prosperous in all respects.

Based on our experience and measurements, application of agroforestry (alley cropping) practice system can significantly increase the efficiency of (artificial) afforestation, reduce the drought damage, and improve the survival and growth parameters of seedlings. By maximising the utilisation of the available area to serve other purposes (production, ecosystem services), the afforestation may be coupled with resource efficiency and economic returns.

Acknowledgement

The authors would like to thank the forestry company participated in this transdisciplinary exercise. We acknowledge the support of the European Commission through the AGFORWARD FP7 research project (contract 613520).

References

Miklós Zs (1974) A Debreceni Vákáncsosok. In: A Déri Múzeum Évkönyve. *Debrecen*, Pp.260-264.

Nagy G (2014) A Talaj Nedvességtartalmának Meghatározása Az Elektromos Vezetőképesség Vizsgálatával. Nyugat-Magyarországi Egyetem Mezőgazdaság- És Élelmiszertudományi Kar, Mosonmagyaróvár. http://Www.Hidrologia.Hu/Ifjusaginapok/22/Dolgozatok/Word/29_Nagy.Pdf (accessed 18/04/2018).

Vityi A, Kovács K, Dufla F, Bácsmegi L, Nagy I (2016) Improve the efficiency of afforestation by the use of agroforestry practices. 3rd European Agroforestry Conference, Montpellier, France.